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tively, and it is symmetrical; for this work, however, where flatness of field is necessary, I do not think it can be so good as either of the other forms. The second arrangement is peculiar, and with a mirror of 5-foot aperture the supports of such a second mirror might be difficult; on the other hand, the loss of reflecting surface can be made up by a trifling increase of diameter in comparison with other forms. The connection between the mirrors can be made very rigid as they are so near, the surfaces can be wrought to suit each other and to give a flat field in addition, all is symmetrical, and that is important, and the plate is in a convenient place for exposure under examination, and is quite protected by the smaller mirror from the direct light of the sky.

The largest instrument of this kind that I have tried has a concave mirror of $9\frac{1}{2}$ inches, and a smaller mirror of $4\frac{1}{2}$ inches diameter; the focal length of large mirror is 43 inches. This instrument, roughly mounted in a wooden box, and attached to the 6-inch telescope, forms a photographic telescope that will give a picture of an 11 mag. star in thirty minutes under very unfavourable circumstances. The field of view is 3° only, as the hole that I cut in the large concave is not larger, but as far as it goes it is good. Altogether the arrangement has been more satisfactory than I expected, and I intend to try larger sizes to see if any new features become developed.

The third arrangement I have not tried with photography, but it is quite possible that it may be the best for this purpose. I have tried it on artificial stars, and the way in which the second mirror corrects the astigmatism due to the oblique position of the large one is most remarkable. I cannot find very much information about it, though, no doubt, some exists. I mention it and the other form in the hope that some one may make some trials of it for photography, as it is important to have all the information possible as to the best kind of telescope for this purpose, and this can be best done by many independent experiments. It appears to me that the aim ought to be the production of photographic charts made up of separate fields of 4°, 5°, or 6°, or even more if it be possible, on a scale at least twice that of Argelander's Atlas, and including stars of the 12th magnitude, and this with a moderate exposure.

I believe this, and more than this, to be now possible, but it is necessary that the best way to do it should be clearly shown.

Note on a Method of giving Long Exposures in Astronomical Photography.

By A. A. Common.

In exposing a sensitive plate for a long time the image is liable to shift, from the driving clock not keeping pace with the diurnal motion, from change in the apparent place of the object due to refraction, from change in the position of the focal plane

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due to alterations of temperature, and in the case of reflectors from changes of position of the mirrors due to different strains coming into play as the telescope moves round. None of these movements are very large or come into play quickly, but if allowed to act without immediate correction they will spoil the picture.

In the case of small instruments it is only necessary to watch the object in the finder, and use the fine movements of the telescope as required; but in large heavy instruments, and particularly in the case of reflectors, this cannot be done, the connection between the finder and the mirrors being at all times bad. When using a large reflector for long exposures, as in taking the nebula photographs, I used an apparatus that I devised for watching and correcting any errors of movement in the telescope, which is so simple and efficient, that a description may be useful to those who contemplate work similar to that for which I used it. In this case the image of a star as near as may be to the object to be photographed, formed by the same mirror as produces the picture, was observed, and by means of cross-wires attached to the same slide that held the plate, and moving with it, the cross-wires and the plate were kept constantly in one position with regard to this star, and consequently to the image falling on the plate.

The general arrangement may be thus described. On the tube that fits the eyepiece end a plate is fixed, carrying two slides capable of movement by means of fine screws in directions at right angles, in the manner of the ordinary slipping piece in use with a micrometer. The upper slide is for carrying the plate holder, and has two screws to hold it in position. A box is fixed to this slide to carry the cross-wires and eyepiece; in the box there are three grooves—the lower one carrying the cross-wires, the next a plate of glass to protect them from the breath of the observer, and the other to carry the eyepiece. The cross-wires and the eyepiece can be placed at any point in the length of the box so as to be more easily placed on a suitable star. A lamp is attached to the end of this box to illuminate the cross-wires in the usual manner. If through any cause it is necessary to interrupt the exposure, it is only necessary to close the shutter of the plate-holder, and then before opening it again to see that the cross-wires are exactly on the image of the star. I have often had to so interrupt a long exposure, but I have never found that the apparatus failed to act perfectly.

I do not think that long exposures can be made, especially with reflectors, without some such arrangement as this to prevent injurious shift of the image; and the larger the telescope the more important it would become, as the movements due to the strains in the mounting would be greater. It becomes, therefore, interesting to consider how this could be done in the case of a large reflector when it is determined to place the plate in the centre of the tube (using this word in its proper sense as applied to reflectors) at the principal focus of the great mirror, and work the correcting apparatus from below, entirely dispensing with any platform or tower for the observer. This arrangement would be the most simple and probably the best that could be used; there would be but one reflecting surface, and everything would be symmetrical. To work the apparatus for correcting during exposure by keeping the cross-wires rigidly on the star, to open and close the shutter, and, above all, to exactly focus the plate, seems at first a difficult thing to do by an observer placed, it may be, fifty or sixty feet away; but by means of small electro-motors these things can be easily done. There is of course behind the plate a good deal of space available for the mechanical arrangements, and the details would not offer any difficulty to any one to work out; and as the power would be conducted by thin wires, much less obstruction would be offered by these than by any other merely mechanical arrangement; in fact, the wires that support the apparatus would do for the conductors. With the optical arrangement that would be necessary there would not be any particular difficulty.

The two things that are required are, that the focussing be accurately done, and that the image of the cross-wires and the star should be as plainly seen by the observer on the ground, as if he were observing them with an eyepiece directly. If the power is sufficient, the same apparatus that is used to observe the star and wires will do to focus the plate by simply focussing the star accurately, and then moving the wires previously adjusted to the same plane as the sensitive plate, until they are also in focus.

There are several ways in which this could be done. The simplest would be to fix two right-angled prisms, one on the apparatus behind the cross-wires, where the eyepiece is in the aforesaid arrangement, and one outside the tube in a similar place to the eyepiece in a Newtonian reflector, so that an object-glass of 4 or 6-in. aperture placed at its focal distance from the image of the cross-wires would send the collected rays on, parallel to another object-glass near the lower end of tube, that would bring them to a focus in a convenient place for observation. There are of course other optical arrangements that would do, but this would, I think, be found to answer well.

Ealing: 1884, *Nov.*

A Remarkable Configuration of Stars in the Milky Way detected by Photography. By Rev. T. E. Espin, B.A.

In October last year some experiments were undertaken by me with a view to photographing large fields of stars, and reducing the photographic magnitudes from the plates. By the courtesy of Professor E. C. Pickering I was allowed to see the negatives that he had with him during his visit to Europe. Early in